CLAIMS

I claim:

1. A method for joining a first metal surface to a second metal surface, said method comprising the steps of:

a) applying a plurality of hard particles to at least a portion of one of the first and second metal surfaces, wherein the plurality of hard particles include a substance that is harder than either metal surface;

b) disposing a non-conductive adhesive on one or both of the metal surfaces;

c) aligning the metal surfaces to form an interface;

d) applying compressive force to the first and second metal surfaces in a direction generally normal to said interface, such that at least a piercing portion of the plurality of hard particles penetrate through the adhesive and pierce the second metal surface; and

e) at least partially releasing the compressive force, the first and second surfaces thereafter being secured together by said adhesive, wherein the piercing portion of the plurality of hard particles remain in piercing relationship with at least a portion of the second metal surface.

2. A method as described in claim 1, wherein the joining of the first and second metal surfaces results in an electrical coupling between the first and second metal surfaces.

3. A method as described in claim 1, wherein the joint results in thermal coupling between the first and second metal surfaces.

4. A method as described in claim 1, wherein the non-conductive adhesive is applied to the second metal surface.

5. A method as described in claim 1, wherein the non-conductive adhesive is applied to the first metal surface.

6. A method as described in claim 1, wherein the non-conductive adhesive comprises a film that is disposed on at least one of the two surfaces at the time of assembly.

7. A method as described in claim 1, wherein the non-conductive adhesive comprises a permanently hardenable adhesive that is hardened before the compressive force is removed.

8. A method as described in claim 1, wherein the non-conductive adhesive comprises a pressure-sensitive adhesive.

9. A method as described in claim 1, wherein the non-conductive adhesive comprises a hot-melt adhesive.

10. A method as described in claim 1 wherein a permanent adhesive bond is formed.

11. A method as described in claim 1 wherein a temporary adhesive bond is formed.

12. A method as described in claim 1, wherein the hard particles are affixed to the first surface by plating a thin metal layer over them on the first metal surface.

13. A method as described in claim 1, wherein the hard particles comprise a hard core surrounded by a softer metal.

14. A method as described in claim 1, wherein the hard particles comprise a metal.

15. A method as described in claim 1, wherein the hard particles are selected from the group consisting of: , copper, aluminum, nickel, tin, bismuth, silver, gold, platinum, paladium lithium, beryllium, boron, sodium, magnesium, potassium,

calcium, gallium, germanium, rubidium, strontium, indium, antimony, cesium, barium, and intermetallics and alloys of these metals.

16. A method as described in claim 1, wherein the hard particles comprise a non-metallic material.

17. A method as described in claim 1, wherein at least one of the metal surfaces comprises an electrical interconnection pad of a printed circuit board.

18. A method as described in claim 17, wherein the printed circuit board comprises a smart card or smart label.

19. A method as described in claim 1, wherein at least one of the metal surfaces comprises the electrical interconnection pad or lead of an electrical component.

20. A method as described in claim 19, wherein the electrical component comprises a semiconductor chip.

21. An electrical component assembly comprising:

a) a substrate having a plurality of electrical contact sites on a surface thereof; and

b) a plurality of hard particles positioned on the substrate, such that each of the electrical contact sites has at least one hard particle associated therewith, the hard particles being affixed to the electrical contact sites.

22. An electrical component assembly as described in claim 21, wherein the plurality of hard particles is affixed to the electrical contact sites by a layer of plated nickel.

23. An electrical component assembly as described in claim 21 further comprising an non-conductive adhesive material applied to at least selected portions of the surface of the substrate and the plurality of hard particles.

24. An electrical component assembly as described in claim 23, wherein the non-conductive adhesive covers substantially all of the substrate.

25. An electrical component assembly as described in claim 23, wherein the non-conductive adhesive covers selected portions of the substrate.

26. An electrical component assembly as described in claim 23, wherein the plurality of hard particles is affixed to the electrical contact sites by plating a thin metal layer over the plurality of hard particles on the electrical contact sites.

27. An electrical component assembly as described in claim 21, wherein the substrate comprises a semiconductor chip.

28. An electrical component assembly as described in claim 21, wherein the hard particles are selected from the group consisting of: diamond, nickel-plated diamond, garnet and silicon carbide.

29. A method for making an electrical component assembly comprising the steps of:

a) providing a substrate having a plurality of electrical contact sites on a surface thereof;

b) positioning a plurality of hard particles on the substrate, such that each of the electrical contact sites has at least one hard particle associated therewith; and

c) affixing each hard particle to its associated contact site.

30. A method as described in claim 29, further comprising the step of applying an non-conductive adhesive material to at least selected portions of the surface of the substrate and the plurality of hard particles.

31. A method as described in claim 30, wherein the non-conductive adhesive covers substantially all of the substrate.

32. A method as described in claim 29, wherein the step of affixing comprises plating a thin metal layer over the plurality of hard particles on the electrical contact sites.

33. A method as described in claim 29, wherein the substrate comprises a semiconductor chip.

34. A method as described in claim 29, wherein the substrate comprises a printed circuit board.

35. A method as described in claim 29, wherein the substrate comprises a smart card chip module.

36. A method as described in claim 30, wherein the substrate comprises a smart label.

37. A method for making an electronic component assemblies comprising:

a) providing a substrate having a plurality of electronic components thereon, each component having a plurality of electrical contact sites on a surface thereof;

b) positioning a plurality of hard particles on the substrate, such that each of the electrical contact sites has at least one hard particle associated therewith;

c) affixing each hard particle to its associated contact site; and

d) dividing the substrate into at least two electrical component assemblies.

38. A method as described in claim 37, further comprising applying a nonconducive adhesive to cover substantially all of the substrate.

39. A method as described in claim 37, further comprising applying a nonconductive adhesive to cover selected portions of the substrate.

40. A method as described in claim 37, wherein positioning a plurality of hard particles comprises affixing the hard particles to the electrical contact sites by plating a thin metal layer over the hard particles on the electrical contact sites.

41. A method as described in claim 37, wherein the substrate comprises a semiconductor wafer.

42. A method as described in claim 37, wherein the substrate comprises a flexible tape printed circuit board.

43. A method as described in claim 37, wherein the substrate comprises a smart card chip module.

44. A method as described in claim 37, wherein the substrate comprises a smart label flexible tape.

45. A method as described in claim 37, further comprising applying a non-conductive adhesive material to at least selected portions of the surface of the substrate and the hard particles, before subdividing the substrate.

46. A method as described in claim 37, further comprising applying a non-conductive adhesive material to at least selected portions of the surface of the substrate and the hard particles, after subdividing the substrate.

47. A method for attaching an electrical component to a printed circuit board comprising the steps of:

a) providing a printed circuit board having a plurality of electrical contact sites on a surface thereof;

b) providing an electrical component having a plurality of electrical contact sites on a surface thereof, each electrical contact site on the electrical component having a corresponding electrical contact site on the surface of the printed circuit board, the electrical component further comprising a plurality of hard particles positioned on the electrical component, such that each of the electrical contact sites

located on the surface of the electrical component has at least one hard particle associated therewith, the hard particles comprising a substance that is harder than the electrical contact sites on the surface of the printed circuit board, the hard particles being affixed to the electrical contact sites;

c) disposing a non-conductive adhesive on at least one of the electrical component and the printed circuit board, such that at least selected portions of the surfaces of the printed circuit board and the electrical component and the plurality of hard particles are covered by non-conductive adhesive;

d) positioning the electrical component relative to the printed circuit board, such that at least one hard particle on each contact on the substrate is in contact with the corresponding electrical contact site on the printed circuit board;

e) applying a compressive force to the component and printed circuit board so that the hard particles on the component penetrate the non-conductive adhesive and pierce into the electrical contact sites on the printed circuit board; and

f) releasing the applied compressive force, a force thereafter being maintained on the surfaces by the non-conductive adhesive, wherein the piercing portion of the hard particles remain embedded in the electrical contact sites on the printed circuit board.

48. A printed circuit interconnection assembly comprising:

a printed circuit board substrate having a plurality of electrical contact sites on a surface thereof; and

a plurality of hard particles positioned on the substrate, such that each of the plurality of electrical contact sites has at least one hard particle associated therewith, wherein the at least one hard particle is affixed to each electrical contact site.

49. A printed circuit interconnection assembly as described in claim 48 further comprising a non-conductive adhesive material applied to at least selected portions of the surface of the substrate and to the plurality of hard particles.

50. A printed circuit interconnection assembly as described in claim 49, wherein the adhesive covers substantially all of the substrate.

51. A printed circuit interconnection assembly as described in claim 48, wherein the plurality of hard particles further comprises a plated thin metal layer that affixes the plurality of hard particles to the electrical contact sites.

52. A printed circuit interconnection assembly as described in claim 48, wherein the printed circuit board substrate comprises a flexible printed circuit board substrate.

53. A printed circuit interconnection assembly as described in claim 48, wherein the printed circuit board substrate comprises a smart card chip module.

54. A printed circuit interconnection assembly as described in claim 48, wherein the printed circuit board substrate comprises a smart label.

55. A method for attaching an electrical component to a printed circuit board comprising the steps of:

a) providing an electrical component having a plurality of electrical contact sites on a surface thereof;

b) providing a printed circuit board having a plurality of electrical contact sites on a surface thereof, each electrical contact site on the board having a corresponding electrical contact site on the surface of the electrical component, the printed circuit board further comprising a plurality of hard particles positioned on the printed circuit board, such that each of the electrical contact sites located on the surface of the board has at least one hard particle associated therewith, the hard particles comprising a substance that is harder than the electrical contact sites on the surface of the electrical component, the hard particles affixed to the electrical contact sites;

c) disposing a non-conductive adhesive on at least one of the electrical component and the printed circuit board, such that at least selected portions of the surfaces of the electrical component and the printed circuit board and the plurality of hard particles are covered by the non-conductive adhesive;

d) positioning the electrical component relative to the printed circuit board, such that at least one hard particle on each contact on the printed circuit is in contact with the corresponding electrical contact site on the electrical component;

e) applying a compressive force to the component and printed circuit board so that the hard particles on the board penetrate the non-conductive adhesive and pierce into the electrical contact sites on the component; and

f) releasing the applied compressive force, a force thereafter being maintained on the surfaces by the non-conductive adhesive, wherein the piercing portion of the hard particles remaining embedded in the electrical contact sites on the printed circuit board.

56. A method for plating hard particles onto a substrate comprising:

providing a metal plating solution including hard particles in a plating tank;

positioning an anode submerged in the plating solution;

positioning the substrate in proximity to the anode;

agitating the metal plating solution; and

plating metal and hard particles onto the substrate.

57. A method as described in claim 56, further comprising:

providing a particle solution reservoir containing a make-up solution comprising additional hard particles and additional metal plating solution, wherein the particle solution reservoir is coupled to the plating tank by a drain and a recirculation conduit; and

recirculating make-up solution through the recirculation conduit to the plating tank,

whereby the step of agitating is provided by the step of recirculating the make-up solution through the plating tank.

58. A method as described in claim 56, wherein the hard particles comprise metal particles.

59. A method as described in claim 58, wherein the metal particles comprise particles selected from the group consisting of: , copper, aluminum, nickel, tin, bismuth, silver, gold, platinum, paladium lithium, beryllium, boron, sodium, magnesium, potassium, calcium, gallium, germanium, rubidium, strontium, indium, antimony, cesium, barium, and intermetallics and alloys of these metals.

60. A method as described in claim 56, wherein the hard particles comprise non-metallic particles.

61. A method as described in claim 60, wherein the non-metallic particles comprise particles selected from the group consisting of: garnet, diamond, and silicon carbide.

62. A method as described in claim 56, wherein the hard particles comprise particles having a hard core surrounded by a softer metal material.

63. A method as described in claim 62, wherein the hard particles comprise nickel-coated diamond particles.

64. A method as described in claim 56, wherein the metal plating solution comprises a nickel plating solution.

65. A method as described in claim 56, wherein the anode comprises a mesh structure.

66. A method as described in claim 56, wherein the anode comprises platinum coated titanium.

67. A method for plating hard particles onto a flexible tape substrate comprising:

providing a particle plating solution including hard particles in a plating tank;

positioning an anode in the plating solution;

agitating the particle plating solution;

drawing the flexible circuit tape through the particle plating solution in proximity to the anode; and

plating a layer of hard particles onto the flexible tape substrate.

68. A method as described in claim 67, further comprising:

providing a particle solution reservoir containing a make-up solution comprising additional particle plating solution, wherein the particle solution reservoir is coupled to the plating tank by a drain and a recirculation conduit; and

recirculating make-up solution through the recirculation conduit to the plating tank,

whereby the step of agitating is provided by the step of recirculating the make-up solution through the plating tank.

69. A method as described in claim 67 further comprising:

drawing the flexible tape substrate through a second plating bath; and

plating a layer of metal onto the layer of particles.

70. A method as described in claim 69, wherein the second plating bath plates a layer comprised of nickel onto the layer of particles.

71. A method as described in claim 69 further comprising:

drawing the flexible tape substrate through a third plating bath; and

plating a second layer of metal onto the layer of particles.

72. A method as described in claim 71, wherein the third plating bath plates a layer comprised of gold onto the layer of particles.

73. A method as described in claim 67 further comprising drawing the flexible tape substrate through a cleaning bath before drawing the flexible tape substrate through the particle plating bath.

74. A method as described in claim 67 further comprising drawing the flexible circuit tape through an etching bath before drawing the flexible tape substrate through the particle plating bath.

75. A method as described in claim 67 further comprising:

drawing the flexible tape substrate through a preliminary plating bath before drawing the flexible tape substrate through the particle plating bath; and

plating a preliminary layer of metal onto the flexible tape substrate.

76. A method as described in claim 75, wherein the preliminary plating bath plates a layer comprised of nickel onto the flexible tape substrate.

77. A method as described in claim 67, wherein the flexible tape substrate is at least partially covered by a layer of photoresist, the method further comprising drawing the flexible tape substrate through a photoresist removal bath after drawing the flexible tape substrate through the particle plating bath.

78. A method as described in claim 77 further comprising drawing the flexible tape substrate through a second cleaning bath after drawing the flexible tape substrate through the photoresist removal bath.

79. A method as described in claim 78 further comprising drawing the flexible tape substrate through an etching bath after drawing the flexible tape substrate through the second cleaning bath.

80. A method as described in claim 67, wherein the flexible tape substrate comprises a flexible circuit tape.

81. A method as described in claim 67, wherein the flexible tape substrate comprises a flexible tape with small rigid components affixed to and spaced apart along a surface of the flexible tape.

82. A method as described in claim 67, wherein the anode comprises a mesh structure.

83. A method as described in claim 67, wherein the anode comprises platinum coated titanium.

84. A method as described in claim 67, wherein the particle plating solution comprises a metal plating solution including hard particles.

85. A method as described in claim 84, wherein the metal plating solution comprises a nickel plating solution.

86. A method as described in claim 67, wherein the hard particles comprise metal particles.

87. A method as described in claim 86, wherein the metal particles are selected from the group consisting of: , copper, aluminum, nickel, tin, bismuth, silver, gold, platinum, paladium lithium, beryllium, boron, sodium, magnesium, potassium, calcium, gallium, germanium, rubidium, strontium, indium, antimony, cesium, barium, and intermetallics and alloys of these metals.

88. A method as described in claim 67, wherein the hard particles comprise non-metallic particles.

89. A method as described in claim 88, wherein the non-metallic particles comprise particles selected from the group consisting of garnet, diamond and silicon carbide.

90. A method as described in claim 67, wherein the hard particles comprise particles having a hard core surrounded by a softer metal material.

91. A method as described in claim 90, wherein the hard particles comprise nickel-coated diamond.

92. A method as described in claim 90, wherein the step of plating further comprises the step of charging the flexible tape substrate as a cathode.